U. S. FOREST SERVICE

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NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

Folwell Avenue, St. Paul, Minnesota 55101

AN INEXPENSIVE TEMPERATURE-GRADIENT INCUBATOR

ABSTRACT. — Describes the use and construction of an inexpensive temperature-gradient incubator.

OXFORD: 44—015.7. KEY WORDS: plant pathogenic fungi, lethal temperature, fungal spore germination.

Most temperature-gradient incubators consist fundamentally of a long bar of aluminum that is heated at one end and chilled at the other. Soldering iron elements (Oppenheimer and Drost-Hansen 1960), hot water baths (Barbour and Racine 1967; Leach 1967), and strip and cartridge heaters (Elliott and Heiniger 1965; Landman *et al.* 1962) have been used as heat sources; immersion in a cold water bath (Barbour and Racine 1967), dry ice cooling (Dimmick 1965), and circulating chilled water through channels cut in the end of the bar (Oppenheimer and Drost-Hansen 1960) have been used for cooling.

We have developed a low-cost temperature-gradient incubator that we feel is superior to many of the others. This one also consists of an aluminum bar heated at one end and cooled at the other. Several heating tapes wound tightly around one end provide the heat source. This eliminates the periodic replenishment of water required with a hot water bath and the necessity of drilling channels in the bar. Cooling of the other end is accomplished by placing it in an ice chest containing polyethylene glycol chilled through the use of refrigerator coils. This coolant was used to prevent ice buildup on the coils.

With our temperature-gradient incubator we have determined growth ranges and lethal temperatures for several plant pathogenic fungi, and have studied the effect of temperature on fungal spore germination. Details of our incubator follow.

INCUBATOR CONSTRUCTION

The dimensions of the aluminum bar are 1.6 by 30 by 152 cm. A 45-degree bend was made 13 cm. from one end of the bar; this end extended downward into a picnic-type ice chest (fig. 1). Polyethylene glycol coolant was added to cover the end of the bar, and a laboratory stirrer was used to stir the coolant. The cooling system obtained from a surplus refrigerator was set to run continuously. At the other end of the bar three 91-cm. heating tapes were wound around the bar and covered with urethane foam insulation. The bar was grounded for safety.

Temperature sensing along the bar was done with thermistor probes either taped to the bar surface or implanted in plastic petri plates, which had holes bored in their sides. Distilled water was added to cover the sensors inside the petri plates and the plates were then placed along the bar. Gross changes in the temperature gradient over the bar could be maintained by varying the number of heating tapes in use. A range of —1° to 35° C. could be achieved along the bar by using one heating tape. A lower temperature range, from —7° C. to ambient, was achieved by turning off all heating tapes. The range below freezing was difficult to use because ice built up on the aluminum bar at these temperatures.

Although the bar was insulated to prevent heat loss with 2-inch-thick sheets of polystyrene foam, the temperature gradient sometimes would be changed by opening the door of the room in which the bar was housed. To eliminate such temperature fluctuations, a polyethylene-covered chamber was constructed around the bar. To provide access and facilitate working on the bar, sliding glass doors were installed

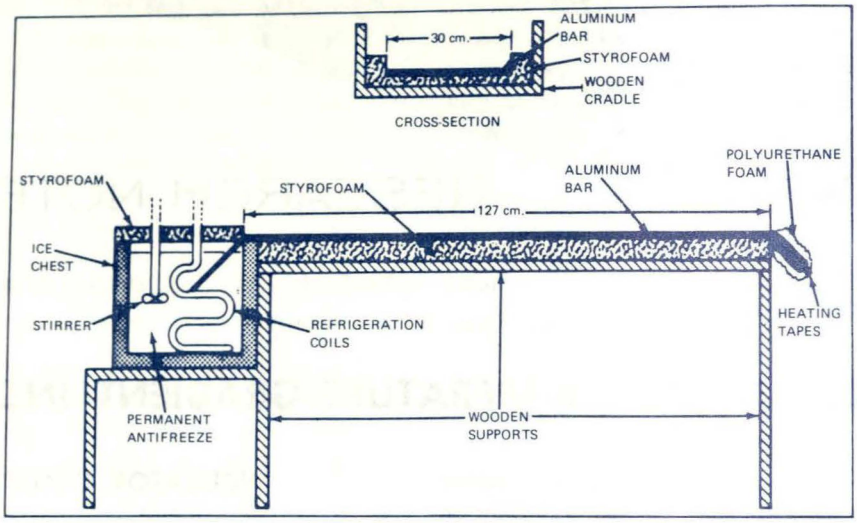

Figure 1. — *Schematic diagram of temperature-gradient incubator.*

at the front of this chamber. With the cooling system running continuously and the chamber temperature constant, temperature variation at sampled points on the bar was less than 0.25° C.

The gradient bar has been used to determine growth ranges and lethal temperatures for several fungi. However, for determining radial growth rates of petri-plate cultures at fixed temperatures, the bar has not proved entirely satisfactory, because the fungi grow along temperature gradients. Therefore, using small fungal growth chambers and measuring growth for short distances have proved desirable for measuring growth at fixed temperatures. For spore germination or small seed germination studies, glass vials with a shallow liquid or nutrient layer can be used as growth chambers with good results.

This gradient bar could be improved by welding a piece of bar at right angles to the cold end instead of bending the bar as we did. Another improvement would be to have a variable resistor to change temperatures at the hot end.

If a surplus cooling unit can be obtained, our temperature-gradient incubator can be constructed for less than $150. The most costly item is the aluminum bar (our bar cost $75 in 1968).

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KENNETH J. KESSLER, JR.
Principal Plant Pathologist
St. Paul, Minnesota
RICHARD W. BLANK
Biological Laboratory Technician
Rhinelander, Wisconsin

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